

THE BRIDGE FROM COLD FACTS AND HOT RHETORIC
TO RATIONAL CLIMATE POLICY

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ABSTRACT: The academic community must expand its role in the political debate over Climate Change policy. The field is characterized by a cacophony of competing scientific claims, scare tactics, and propaganda. Scientists, particularly those in the academy, are badly needed in the role of upholders of the principles of scientific inquiry and standards of evidence upon which rational public policy depends. They should weigh into the conflict more heavily, not on one side or the other, but to point out when the participants on either side are exceeding the bounds of rational analysis. This will not only contribute to more informed policy but also preserve the integrity of science which is essential for continued human progress.

PAPER:

The theme of my presentation concerns the importance of academic and intellectual institutions, a category which clearly includes the American Chemical Society, to the scientific and policy debate over Climate Change and the Kyoto Protocol.

These institutions are much more than simply private associations of their members. They are also major *public* institutions, dedicated to public service as well as to research and education. This role requires the institutions, or, more precisely, their members to go beyond the ivory tower of intellectual inquiry by bringing scientific rigor to bear on important national policy debates so that we choose policies that are scientifically defensible and economically realistic.

This is an important function. It is also an exceedingly difficult one. I have a deep respect for science, and for those who devote their lives to it. I learned through a 12-year affiliation with the University of Rochester the power and value of the scientific method -- the clear statement of testable hypotheses, careful testing and evaluation of evidence, gloves-off peer review, and replication. The scientific approach and the pursuit of knowledge have been and will continue to be two of the great engines of human progress. A commitment to seek the truth no matter where the quest leads reflects a calling of the highest order. In the words of Norbert Wiener, the founder of cybernetics, a good scientist "has a consecration which comes entirely from within himself."¹

These values make the objective of combining science with relevance to the current Climate Change debate not only lofty but also daunting. The scientific values of careful statement, reliance on evidence, relentless pursuit of truth, and willingness to confess error sadly are not the currency of the political marketplace. Indeed, too often the values that hold sway in politics are the exact reverse of those that govern the scientific enterprise. Science in public policy is used increasingly as a campaigning enterprise instead of a means of measuring evidence and seeking truth. As a Nobel laureate recently observed, in science facts matter and perceptions are negotiable while in politics perceptions matter and facts are negotiable.

In 1961, the distinguished historian Daniel J. Boorstin published a prescient book called *The Image: A Guide to Pseudo-Events in America*.² Its thesis is that many aspects of American life, including politics, are losing their connection to reality. Instead, they are dominated by "pseudo-events," events staged to attract the attention of the megaphone of the media, and which manipulate opinion by exploiting the gap between what we need to know and what we can know.

If Boorstin was worried in 1961, when his book appeared, he must be horrified by today's world. The triumph of Gresham's Law seems complete as the false coin of image drives out the gold of truth. The spinners often seem actively hostile to thinking about reality, as if any need to consider truth would only inhibit their creativity in crafting an image to promote what they judge to be worthy goals. We are living in a time in which the belief that the end justifies the means is all too frequently dominant.

One of the most disturbing aspects of the debate over Climate Change is the extent to which it has been driven by pseudo-events and pseudo-arguments. These are displacing good science and reliance on evidence with synthetic truths and treating as settled matters that are extremely uncertain.

This may sound like rhetoric, so let me provide some examples.

First, I will begin with a few things that are known about Climate Change. The Greenhouse Effect is indeed a fact. Certain gases, such as CO₂ and -- far more important -- water vapor do trap some of the sun's warmth. This is a good thing, since without it the temperature of the earth would be about zero degrees Fahrenheit.

Second: The temperature of the earth has gone up over the past 150 years by about one degree Fahrenheit. At least, it appears to be about a degree. Measurements from the 19th Century are inexact, so it is hard to be sure, but we are certain it has increased.

Fact three: During the past 150 years the atmospheric concentration of CO₂ has risen from about 278 parts per million to 365 ppm. It is commonly stated as a certainty, but the methodology underlying the estimates of CO₂ concentrations in the 19th Century has been criticized as possibly underestimating these pre-industrial levels, and thus overstating the increase.³ It is clear that we are only beginning to understand the complexities of the global carbon cycle.

Now, those three facts exhaust most of what is known with reasonable certainty about the risk of human-induced Climate Change. Everything else is immersed in a sea of uncertainty and subject to debate. For example, it is often stated that human activity has caused the increase in CO₂ concentration because burning fuel releases CO₂. This is a reasonable hypothesis — and I stress *hypothesis*. But other hypotheses are also reasonable. There is strong evidence that at times in the history of the earth, CO₂ concentrations were as much as 20 times as high as they are today, and this was long before the age of fossil fuels.⁴

Take another “known fact” that is simply another hypothesis: It is asserted that since CO₂ concentrations have gone up over the past century, and so has the temperature, then the CO₂ caused the temperature rise. This sounds logical, but it does not fit the data or climate history. Most of the rise in temperatures occurred before 1940, and thus preceded most of the increase in CO₂ concentration. Despite the increase in CO₂, over the past 20 years, highly accurate satellite data show no increase in lower atmosphere temperature. And, satellite data closely correlate with weather balloon measurements.

So, to what do we attribute the rise in temperature over the past century? One hypothesis that fits the data is that increases in temperature are correlated with solar activity — sun spots.⁵ And it is entirely possible that the chain of causation is the reverse of conventional wisdom — rises in temperature might cause increases in CO₂ concentrations as the oceans re-balance. Finally, the end of the last century marked the end of a “little ice age,” so natural variability is a major factor in explaining this century’s temperature increase.

If you start with the assumption that CO₂ is primarily responsible for the rise in temperature over the past century, then it is also logical to assume that further increases in the release of greenhouse gases will cause further rises in temperature. This is a legitimate concern but it still is only a hypothesis. The models that predict warming as a result of increases in greenhouse gases (GHGs) rely heavily on assumptions about a water vapor feedback cycle, assumptions that have little empirical basis. If this feedback cycle does not exist or was modest then increases in GHG concentrations would have very little impact on temperature.

The list of other “facts” that turn out to be less than solid grow with the intensity of the rhetoric. Mark Twain once observed that he wasn’t troubled by all the things that people don’t know. He was troubled by all the things they do know that just aren’t so. This applies to Climate Change. Predictions of the rise in temperature to be expected as a result of human activity has been steadily reduced. In 1990, the Intergovernmental Panel on Climate Change (IPCC) best estimate was an increase of 3.2° C. by the year 2100. Five years later, the estimate was down to a 2.0° C. But this does not reflect the latest research. Some observers believe that advances in knowledge and models should reduce the best estimate to 1° C.

In spite of reduced estimates of temperature increase, dubious predictions abound. One reads that global warming will cause catastrophic rises in sea levels, or about an increase in infectious diseases, or rising deaths due to heat waves, or a steady stream of record high temperatures, or more hurricanes and other extreme weather events. None of these bugaboos are probable. Few are even remotely plausible. None are supported by science. All represent the politics of doom to advance through fear an agenda that cannot stand on its own merits.

Since in our Alice in Wonderland paradigm, policy is based on “sentence first, trial afterwards,” it is important that scientists become more involved in this debate. And it is crucial that they maintain focus on applying the rigors of science, because they have a powerful role to play in helping to re-focus the debate back on rationality, evidence, and fact. Scientists can take a lead in applying relentless skepticism to the claims of all parties, because of a primary allegiance to truth, to reality. Most of the parties to the debate have interests that expose them to temptation to subordinate objective reality to their particular interests. Knowing that their claims will receive close scrutiny from disinterested scientists is the best way to build resistance to this temptation.

I am not exempting industry from this prescription, either. I represent the petroleum industry, a special interest which has a large economic stake in the outcome of this debate. No one should accept automatically anything said by me or any other industry representative. Whatever the topic, the audience should bring scientific skepticism to bear and ask: “Tell me why you think that — show me the evidence, and show me your logic.”

However, since I am from industry I am used to such skeptical challenging. While I may not always enjoy it, it is good for me, and for others who engage in advocacy. I do not ask that scientists go easy on me. But, in fairness, their vigilance should be extended to others, since it would be equally foolish to accept without question the views of other participants. Advocates of the Kyoto Protocol wrap themselves in robes of concern for the environment. Some of this is real, but some of it is gamesmanship. They are also special interests of various sorts, including

economic ones. Some businesses see the possibility of subsidies, market share, and competitive advantage. Other parties see chances for government grants, foreign travel, and lucrative future consulting. Some government officials see opportunities for power, office, and bureaucratic aggrandizement. Environmental organizations see a lever to promote a broader agenda, one that often crosses the border from concern about the environment into opposition to industrial activity and to the personal freedom and mobility that are among our core values as Americans.

So I urge all scientists to treat everyone's claims with even-handed skepticism.

This role of imposing scientific order and honesty on the public debate is only part of the scientists' job, though. It is surprising how little we know for certain about the Climate Change issue. A serious criticism of the Clinton Administration is for its rush to judgment and hyping of a supposed solution before we even know if a serious problem exists. This has diverted energy from thoughtful efforts to explore the existence and scope of the threat and to develop actions that are consistent with our state of knowledge.

For example, we need to know more about past CO₂ levels. The history of the pre-satellite temperature record needs close scrutiny, and serious concerns about possible distortions need to be resolved. While I have dismissed concerns about extreme weather events, infectious diseases and similar issues, there is no doubt that these are matters of concern to the public. They need continuing scientific attention. Research is needed on solar activity and the mechanism by which solar activity impacts global temperature.

This only begins the list of scientific tasks on Climate Change. We need better climate models to reduce the variability between models and the enormous uncertainty surrounding projected impacts. This means we need more scientific knowledge about the impact of clouds, water vapor feedback cycles, snow and ice accumulation and reflectivity, the phenomenon of desertification, and other scientific dimensions of climate issues.

Often, when I raise these issues I am accused of using scientific uncertainty as an excuse for inactivity and delay. This mis-states the issue and my position. Our choices are not between action or inaction but between responsible and irresponsible actions. Thus my final point concerns the Climate Change issue as a problem in public policy, as a problem in choosing actions that are consistent with our state of knowledge and economic objectives.

My own background is not in science but in economics, business, and policy analysis. To those of my ilk, the details of the Climate Change issue are complicated, but the basic structure of the problem is simple -- Climate Change is a problem in decision-making under conditions of uncertainty. Those of us in business confront similar problems every day, and we know the rules for dealing with them.

The first rule is to be slow to commit. Until you must, do not bet your company (or your country) on something that might turn out to be an error. If at all possible, postpone major decisions while you reduce uncertainties.

Given this rule, the first question to ask is, "Do we have time?" With respect to Climate Change, the answer is clearly, "Yes." We do not need to drastically reduce emissions in the short term because nothing we do in the next 15 or 20 years will have any appreciable impact on the world's average temperature in 2050 or 2100. In fact, nothing the U.S. does in the next 10 or 20 years will have much impact on the atmospheric concentration level of greenhouse gases in the year 2020. According to the former Chairman of the Intergovernmental Panel on Climate Change, the effect of the Kyoto Protocol on CO₂ concentration levels in 2010 is four-tenths of one percent (0.4%). And it would not be much greater in the following decade.

Since concern should be with the total accumulation of CO₂ and not with emissions *per se*, decisions on accelerated reductions in emissions can be safely postponed. This fact is crucial, because the costs of these reductions are exceedingly sensitive to timing. Many capital investments, including those in energy, are long term. If change can be deferred until current equipment reaches the end of its useful life, and can be replaced by more efficient technology, costs will decline drastically.

Recently, some confusion over the potential costs of Kyoto was triggered by the Administration's release of an optimistic study by the Council of Economic Advisors (CEA). The Council reached its rosy conclusion only by three assumptions, all of them unrealistic. It assumed the U.S. could meet 80 per cent of its emission reduction obligations by buying credits from abroad. Put another way, only 20 percent of our obligations would be met by domestic action. The Kyoto Protocol does not provide for this and no mechanism for accomplishing such a result is in place. CEA made two other critical assumptions: First, that there is a truly global emissions trading system in place, even though 138 developing countries are exempted from the Protocol. Second, that electric utilities would largely switch from coal to natural gas in 10 years. This is economically impractical. Dr. Boorstin might call the Council's work a pseudo-analysis.

A more realistic recent appraisal came from the Energy Information Administration, which estimated that Kyoto could, by 2010, raise gasoline prices 53 percent, raise electricity rates 86 percent, and reduce GNP by 4.2 percent.⁶

Make no mistake. A commitment to link decisions on Climate Change to the true state of knowledge and advances in it will produce long term environmental and economic benefits.

This leads logically to the second rule for making decisions under uncertainty: Invest in information. Spend money to narrow the range of possibilities. Use sensitivity analysis — what information forms the hinge of the decision, and how can we get it? We need to invest in gaps in climate science that have been identified by the National Research Council. We need better climate models. We also need to invest in analyzing basic issues. And we need to invest in creating contingency plans.

The third rule is called “no regrets.” Look for actions that will produce benefits under any set of circumstances. Business has developed a list of emission-control and policy actions that will be worthwhile even if the threat of Climate Change turns out to be a hobgoblin, and we have shared it broadly. In contrast, the Administration policy of committing to near-term emissions rollbacks, regardless of the state of knowledge or the timing of investment decisions, is guaranteed to cause a lot of regret.

The final rule is to consider alternatives. It is a truism that the further ahead you try to predict, the greater the number of uncertain factors, and the larger the probability that any single guess will be wrong. This wisdom that a broad net should be cast to be sure that all alternatives are considered certainly applies to Climate Change. Even if the problem turns out to be real, it is likely that a crash program of prevention is the wrong option. In much of the world the impact of warming could be neutral or even benign. In other cases, it might make more sense to commit resources to adaptation. These options need serious consideration and analysis, and serious scientific work. They are not getting it to the extent that they should.

These four rules — use time as a friend rather than an enemy; invest in information; look for “no regrets” actions; consider all the alternatives — provide the basis for a sound national and international policy on Climate Change. Their wisdom is thoroughly supported by the facts and by the logic of a learn, act, learn strategy.

So, to return to my initial theme — the role of scientists — I urge all scientists to hold firm to their scientific habits of mind in their work on the Kyoto Protocol, whether that work takes the form of research, education, or participation in the policy debate. I think the Administration is acting in the unfortunate tradition of political leaders who try, by command or demagoguery, to repeal the laws of reality when these conflict with their ideology.

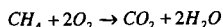
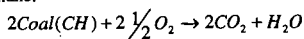
Science and the scientific method should not be campaigning tools, used to gain advantage by promoting fear and stifling debate. As Ted Koppel eloquently observed, in a discussion he had with Al Gore on *Nightline* several years ago: “The measure of good science is neither the politics of the scientists nor the people with whom the scientist associates. It is the immersion of hypothesis into the acid of truth. That’s the hard way to do it, but it’s the only way that works.”

It is heartening that a TV newscaster can be quoted on the importance of science and truth. These values need to be restored as part of the shared consciousness of the society. Actions do have consequences and a frightened society can talk itself into stagnation. Looking at the future, the greatest threats to continued progress are the illusion of knowledge and the corrosive effects of anxiety run amok. It is the job of scientists to replace the illusion with real knowledge, and the anxiety with reason. Beyond producing a more informed climate policy, a renewed commitment to science and engineering provides society with the foundation for human creativity and progress.

NOTES

1. Norbert Wiener, quoted in *Bartlett's*, p. 691.
2. Harper Colophon Books, 1964 (paperback edition).
3. Tom V. Segalstad, “Carbon cycle modeling and the residence time of natural and anthropogenic atmospheric CO₂: on the construction of the ‘Greenhouse Effect Global Warming’ dogma,” in Roger Bate (ed.), *Global Warming: The Continuing Debate*, European Science and Environment Forum, Cambridge, England, Jan. 1998, pp. 184, 187-89.
4. Arthur B. Robinson, Sallie L. Baliunas, Willie Soon & Zachary W. Robinson, “Environmental Effects of Increased Atmospheric Carbon Dioxide,” Jan. 1998 (Published by the Oregon Petition Project).
5. Virginia Postrel & Steven Postrel, “Stars in Her Eyes: An Interview with Sallie Baliunas,” *Reason*, Oct. 1998, p. 42.
6. EIA, *Impacts of the Kyoto Protocol on U.S. Energy Markets and Economic Activity* (Oct. 9, 1998).

unit of combustion products. Two thirds of coal combustion products are CO_2 versus one third of methane.



Therefore, the utilization of the methane contained in natural gas hydrate would not only ensure the adequacy of world energy resources, but would also mitigate global climate change.

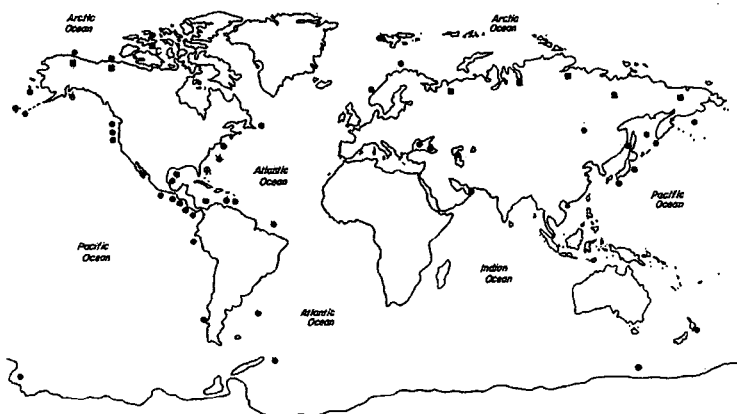


Figure 2. Map of In-Situ Hydrate Locations

Reference: Kvenvolden, K. A., *Chem. Geol.*, 71, 431 (1988).

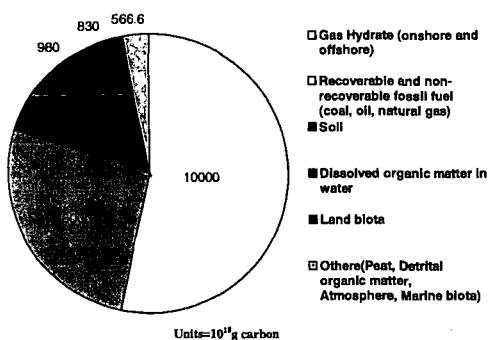


Figure 3. Distribution of organic carbon in earth (excluding dispersed organic carbon such as kerogen and bitumen)

Reference: Keith A. Kvenvolden, *International Conference on Natural Gas Hydrates*, Ann. N. Y. Acad. Sci. vol. 715, 232-246 (1994)

PHASE EQUILIBRIA

For studying about methane gas recovery from hydrates, phase equilibria between the hydrate phase and the gas phase is very important. The fundamental model is based on statistical thermodynamics and developed by van der Waals and Platteeuw (1959). Later, Parish and Prausnitz (1972) modified it and recently, a distortion model was developed by Lee and Holder (1999). Figure 4 shows the three phases curves for several hydrates. Q_1 is the triple point and Q_2 is the quadruple point. As can be seen, low temperature and high-pressure favor hydrate formation.

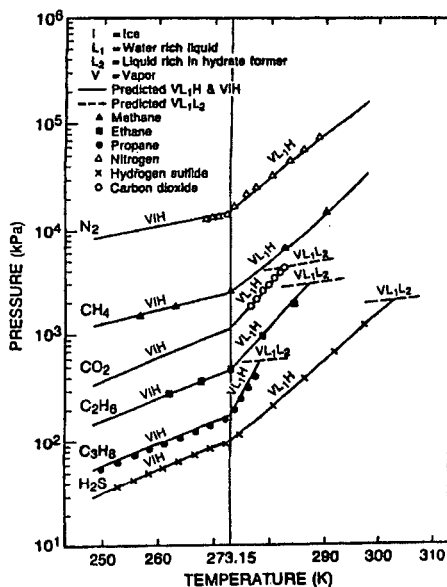


Figure 4. Hydrate Forming Conditions for Several Gases.

Reference: Holder et al., *Review in Chemical Engineering*, Vol. 5, 1-70 (1988).

THE RECOVERY OF GAS FROM HYDRATED RESERVOIRS

First, solid hydrates probably need to be dissociated for gas recovery from hydrates. The dissociated gas can then be transported in the same manner as conventional natural gas. Dissociation of gas hydrates can be accomplished in three ways. The first method is thermal injection, the second is pressure reduction and the last is slurry mining.

When heat is added at constant pressure, the system temperature can rise up to the dissociation temperature. At the dissociation temperature, all heat that is added is spent on hydrate dissociation. The energy required to dissociate hydrate ranges from 50 kJ/mole (for methane) to 130 kJ/mole (for propane) (Holder, 1988). The problem with this method is the heat lost to reservoir rock and water. Without heat loss the injected energy is about 10% of the recovered energy. With heat loss the injected energy may exceed the heating value of the gas. This method is also expensive and has to simultaneously move hot fluid downward and gas upward (Max et al., 1997).

The second technique is the depressurization technique. It operates by lowering the pressure in an adjacent gas reservoir. When the pressure reaches the dissociation pressure, gas hydrates at the interface convert to gas and water. This technique has been used in the Messoyhaka gas field in the western Siberia hydrocarbon province (Max et al., 1997). The last method, slurry mining, has not studied yet but is suggestive of grinding up the ocean bottom to

recover a slurry of solid hydrates which are likely to dissociate in the riser. Holder et al. (1984) notes that depressurization and hot water injection seem to be the most promising techniques for further evaluation because of lower heat losses compare to steam injection.

A complication of producing gas from hydrate is the possible formation of gas hydrates in the transportation lines. There are four thermodynamic ways to prevent hydrate formation (Sloan, 1997). They are 1) remove the water (it can lower the dew point), 2) keep the system temperature higher than hydrate formation temperature, 3) keep the system pressure lower than hydrate formation pressure, and 4) use inhibitors. These methods are used individually or jointly in production operations today.

Recently, research about replacement of naturally occurring methane hydrates with carbon dioxide hydrate has been also studied. Methane gas hydrates need higher pressure to be stabilized compare to carbon dioxide gas hydrates. Over a certain pressure, methane gas hydrate is unstable, while carbon dioxide gas hydrate is stable. However, very complex phase behaviors are likely to make this process difficult.

CONCLUSION

Natural gas, primarily methane is an excellent fuel for combustion for a number of reasons. Methane produces less carbon dioxide per mole than any other fossil fuel when it is used as fuel. Thus, it can reduce the amount of anthropogenic emissions of dioxide gas, which may cause a green house effect. In addition, natural gas contains very little sulfur or phosphates that can cause air pollution. Additionally, the amount of fossil fuel in hydrate form is twice as large as in all other forms. Thus, methane gas hydrate has a potential to be used as a new energy source.

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